C1. A recombinant microorganism is one that contains DNA that has been manipulated in vitro and then reintroduced back into the organism. Recombinant microorganisms have been used to synthesize human gene products (e.g., insulin), as biological control agents (e.g., *Ice*$^{-}$ bacteria), and in bioremediation (e.g., oil-eating bacteria).

C2. *A. radiobacter* synthesizes an antibiotic that kills *A. tumefaciens.* The genes, which are necessary for antibiotic biosynthesis and resistance, are plasmid encoded and can be transferred during interspecies matings. If *A. tumefaciens* received this plasmid during conjugation, it would be resistant to killing. Therefore, the conjugation-deficient strain prevents the occurrence of *A. tumefaciens*–resistant strains.

C3. Bioremediation is the use of microorganisms to eliminate pollutants in the environment. Biotransformation is the conversion of a toxic compound into a nontoxic one. Biodegradation occurs when a toxic compound is broken down into a smaller, less toxic one.

C4. A biological control agent is an organism that prevents the harmful effects of some other agent in the environment. Examples include *Bacillus thuringiensis*, a bacterium that synthesizes compounds that act as toxins to kill insects, *Ice*$^{-}$ bacteria that inhibit the proliferation of *Ice*$^{+}$ bacteria, and the use of *Agrobacterium radiobacter* to prevent crown gall disease caused by *Agrobacterium tumefaciens.*

C5. These medicines are difficult and expensive to purify from human sources. The advantage of genetically engineered organisms is that they can produce a large amount of these medical agents, at a fraction of the cost. There are some disadvantages. For example, a medical agent may require posttranslational modifications that do not occur in microorganisms. Public perception of genetic engineering may also be a problem, although it has not been a big problem in this particular area of genetic engineering.

C6. A mouse model is a strain of mice that carries a mutation in a mouse gene that is analogous to a mutation in a human gene that causes disease. For example, after the mutation causing cystic fibrosis was identified, the analogous gene was mutated in the mouse. Mice with mutations in this gene have symptoms similar to the human symptoms (though not identical). These mice can be used to study the disease and to test potential therapeutic agents.

C7. A transgenic organism is one that has recombinant DNA incorporated into its genome. The FlavrSavr tomato is an example of transgenic plant. Plants resistant to glyphosate are another example. The large mouse shown in Figure 19.4 contains a transgene from a human. Sheep that express human hormones in their milk are also transgenics.

C8. The T DNA gets transferred to the plant cell; it then is incorporated into the plant cell's genome.

C9. Gene addition occurs when a gene is introduced into a cell and it integrates into the chromosomal DNA by nonhomologous recombination. The gene is simply added to the genome. Gene replacement occurs by homologous recombination. In gene replacement, the gene that is introduced into a cell is swapped with a homologous gene that is already present in the genome.

A. This is gene replacement. The normal mouse gene is replaced with a mutant gene.

B. This is gene addition. The T DNA that carries a gene of interest can integrate at various sites throughout a plant genome.

C10. A. With regard to maternal effect genes, the phenotype would depend on the animal that donated the oocyte. It is the cytoplasm of the oocyte that accumulates the gene products of maternal effect genes.

B. The extranuclear traits depend on the mitochondrial genome. Mitochondria are found in the oocyte and in the somatic cell. So, theoretically, both cells could contribute extranuclear traits. In reality, however, researchers have found that the mitochondria in Dolly were from the animal that donated the egg. It is not clear why she had no mitochondria from the mammary cell.

C. The cloned animal would be genetically identical to the animal that donated the nucleus with regard to traits that are determined by nuclear genes, which are expressed during the lifetime of the organism. The cloned animal would/could differ from the animal that donated the nucleus with regard to traits that are determined by maternal effect genes and extracytoplasmic genes. Such an animal is not a true clone, but it is likely that it would greatly resemble the animal that donated the nucleus, because the vast majority of genes are found in the cell nucleus.

C11. See Table 19.5.

C12. Some people are concerned with the release of genetically engineered microorganisms into the environment. The fear is that such organisms may continue to proliferate and it may not be possible to “stop them.” A second fear is the use of genetically engineered organisms in the food we eat. Some people are worried that genetically engineered organisms may pose an unknown health risk. A third issue is ethics. Some people feel that it is morally wrong to tamper with the genetics of organisms. This opinion may also apply to genetic techniques such as cloning, stem cell research, and gene therapy.

C13. Gene therapy, as described in your textbook, is conducted on somatic cells, not on germ-line cells. Therefore, the genes that are introduced into a person’s body via gene therapy cannot be passed to his/her offspring.